

**ENVR 672**  
**Principles of Environmental Physics II**  
**Spring Semester 2016**

## 1 General Information

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## 2 Grading Bases

The bases for assigning grades are as described in the following table; additional detail about these components is given in sections that follow.

Problem Sets:	25%
In Class Participation:	25%
Mid-Term Exam:	25%
Final Exam:	25%

## 3 Introduction

This course is the continuation of a two-semester sequence in environmental physics. The level is appropriate for an advanced undergraduate or early level graduate student. The name “environmental physics” is somewhat unusual. Books with these words in the title are rare and courses by this name are not taught in any other graduate program as far as we know. This seems somewhat strange. Environmental inorganic and organic chemistry, environmental microbiology, environmental policy, etc courses are quite common. Why not environmental physics? Is it that all the relevant physics needed for the study of the environment has been mastered at the undergraduate level? Or is it that the physics needed is so broad and specialized that it is taught in multiple specialized courses that bear different names, such as fluid mechanics, continuum mechanics, solid mechanics, transport phenomena, and process dynamics? If it is the latter, how many typical graduate students are exposed to the breadth of principles covered in this range of courses compared to what fraction of the students could benefit from graduate-level education in physical principles? Another possibility is that physical principles are so important that they are covered in many courses as a part of specialized study in a wide variety of areas. If this is the case, it would seem that we have an inefficient system of graduate education. One other reason could be the lack of a mathematical background on the part of both students and faculty that makes tackling the elements of environmental physics difficult. Thus, “environmental” courses are offered that deal with the outcomes of environmental processes without considering the causes or physical mechanisms of those processes.

Our view is that an essential element of graduate education involves mastering a set of fundamental principles. This mastery should provide sufficient skill to apply these principles to a broad range of systems that could be encountered routinely. Additionally, this mastery should provide

fundamental understanding that will provide a basis for addressing atypical problems or new issues that may develop throughout one's career. Most certainly, a set of physical principles exists that has widespread application in environmental systems. These principles involve concepts that allow for analysis of environmental systems in terms of the simplest possible set of important variables as well as analysis in terms of continuum representations of conservation principles that provide mechanistic representations of the important processes. This course, along with its prequel, is focused on:

- i. exposing participants to this broad set of principles;
- ii. educating participants in their development and application;
- iii. paving the way for more advanced and specialized study in a wide range of speciality areas; and
- iv. cutting across and integrating the many areas of study collectively referred to as "environmental sciences and engineering."

## 4 Course Objectives

Specific objectives for students in this course are the following:

- to understand the broad scope of problems to which the principles of environmental physics can be applied and to appreciate the commonalities that exist among widely varying systems;
- to derive general microscale conservation and balance equations of energy and entropy and be able to simplify them in a manner consistent with the physics of systems of interest;
- to learn principles and applications associated with conservation of energy as applied to a broad range of environmental systems;
- to understand and gain facility with thermodynamics and thermodynamic principles as they apply to the study of environmental systems;
- to be able to formulate descriptions of problems at different scales; and
- to appreciate classes of problems that are not tractable with the principles covered in this course.

## 5 Background Required

The essential pre- or co-requisites for this course are the following:

- calculus through ordinary differential equations;
- partial differential equations;
- calculus-based physics;
- general chemistry;
- computer literacy (e.g., programming in one or more languages, such as Matlab, Mathematica, C++, or FORTRAN); and

- completion of the first course in this sequence, or equivalent.

Students who are deficient in one or more of these areas are not necessarily excluded from participation in this course and may be able to successfully complete the course. However, deficiencies in some areas will require additional commitment and effort to master the material in a way that will provide both intellectual satisfaction and a strong grade.

Because this is an advanced-undergraduate or beginning graduate-level course, it is expected that significant time will be required outside of lecture to master the material covered in the lectures and to complete the problem sets. Also dedication to learning the material is assumed, including seeking additional assistance when needed, helping classmates, and consideration of the context of the material presented in class. Those with an “average” background, should plan to spend about three hours outside of class for each hour of class time. Deficiencies in background will require additional time. However, despite these guidelines, it is important that graduate students understand their classes as an activity designed to encourage intellectual growth. Such growth occurs only through immersion in a subject; it does not occur by compartmentalizing course topics to various hours of the day or using a clock to monitor engagement in a course. Students are encouraged to try to integrate what they see in class to what they observe on the news, in experiences of rain storms, of runoff, of air quality, of water quality, of their environment. Those who become sensitive to their environment and come to understand environmental physics as a context for understanding system behavior will gain the most benefit from the course. In essence, participants are encouraged to make this course a part of their lifestyles!

## 6 Problem Sets

Problem sets will be assigned during the course to expose students to problem solving for a range of topics. Two weeks, or more, will be given to complete each problem set. It is important that this not be understood to mean that a student can rest for a couple of weeks before making a concerted effort to complete an assignment. Work on an assignment should begin when the material is assigned so that difficulties encountered can be opportunities for learning rather than just obstacles that prevent knowledgeable completion of an assignment. Any reference materials, software, or individuals available to the student can be used to complete these problem sets. Discussions and cooperative efforts among class members are encouraged. However, each write-up must be the product of the student submitting the work. Any work handed in must reflect the understanding of the author of the document. Key ideas contributed by others, key references, as well as the names of individuals with whom the work was discussed should be acknowledged in the write-up. Problem sets should be typed and organized, reflecting the ability of the student to prepare a document in a professional manner. The objective of the homework is to facilitate the learning of each student. Therefore, work handed in should reflect what the individual has learned and understands, not what others have learned. Random questioning of students about homework assignments may be used as a learning tool.

## 7 Exams

One mid-term and a final exam will be given in this course. These exams will be open book and open notes.

## 8 Course Text and References

The material covered in this course does not map to any available book, so no book purchase is required. Course notes will be prepared and posted on sakai. References will be suggested in addition to the notes. Books on tensor calculus, fluid mechanics, transport phenomena, continuum mechanics, process dynamics, and a high-level programming language will be of some use. There are many available. Students are asked to notify the instructors of any particularly helpful references they encounter that provide either details or context for this course including journal articles, text books, and popular media.

## 9 Course Calendar

12 January (1)	14 January (2) Problem Set 1 Out
19 January (3)	21 January (4)
26 January (5)	28 January (6) Problem Set 1 Due
02 February (7)	04 February (8) Problem Set 2 Out
09 February (9)	11 February (10)
16 February (11)	18 February (12) Problem Set 2 Due
23 February (13)	25 February (14) Problem Set 3 Out
01 March (15)	03 March Mid-Term Exam
08 March (16)	10 March (17)
15 March Spring Break	17 March Spring Break
22 March (18)	24 March (19) Problem Set 3 Due
29 March (20)	31 March (21) Problem Set 4 Out
05 April (22)	07 April (23)
12 April (24)	14 April (25) Problem Set 4 Due
19 April (26)	21 April (27)
26 April Final Exam	28 April

**Note:** The number enclosed in parenthesis next to the date may be used as a subject reference by comparison to the lecture outline.

## 10 Lecture Outline

The formal in-class portion of this course will consist of 27 lectures. These lectures will address many aspects of environmental physics, building on the topics covered in Environmental Physics I. They will not follow any book specifically, but readings will be suggested. The topics to be covered along with the reference numbers for the lectures on each topic are detailed below:

1. Review of Environmental Physics I (1–2)
2. Conservation of Angular Momentum (3–5)

3. Turbulence (5–18)
4. Mechanical Energy (19–22)
5. Change of Scale Theorems (23–24)
6. System with Reduced Dimensionality (25–27)